

Brookhaven National Laboratory

High Energy Physics Program Physics Beyond the Standard Model

Michael J. Murtagh
HEPAP Meeting
Gaithersburg, Md
March 26, 2001

Outline

■ Theory

■ AGS Experiments

- Present Experiments

- E821 Muon ($g-2$)
- E787/E949 ($K^+ \rightarrow \pi^+ \nu \bar{\nu}$)

- Planned (NSF MRE proposal RSVP)

- KOPIO ($K^0 \rightarrow \pi^0 \nu \bar{\nu}$)
- MECO ($\mu \rightarrow e$ conversion)

■ Fermilab

- D0 (ppbar collider)
- MINOS (Long Baseline Neutrino Experiment)

Outline

■ CERN

- LHC Accelerator
- ATLAS Detector Project
 - ATLAS Project Office
 - Cryostat/Cryogenics
 - Liquid Argon Calorimeter
 - Muon System (Forward Muon System)
- ATLAS Computing
- ATLAS Research Project –Maintenance, Operations and Upgrades

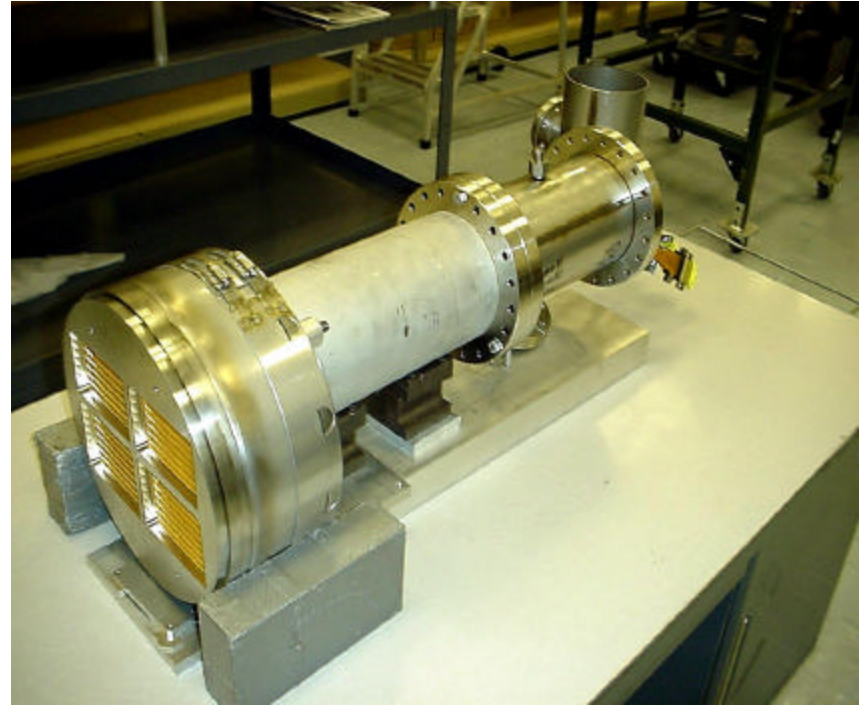
■ Advanced Accelerator R&D

- Muon Collider R&D
 - Target Experiment AGS E951
- Muon Storage Ring Neutrino Beam
 - Site Specific Study II (Brookhaven Site)

ATLAS



Cryostat

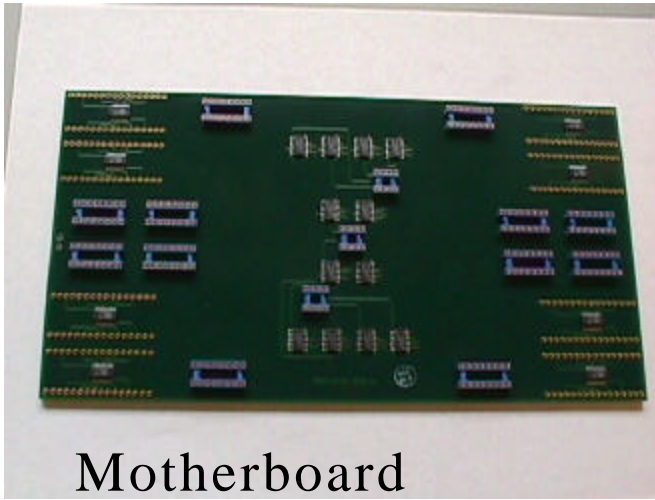


Signal Feedthrough

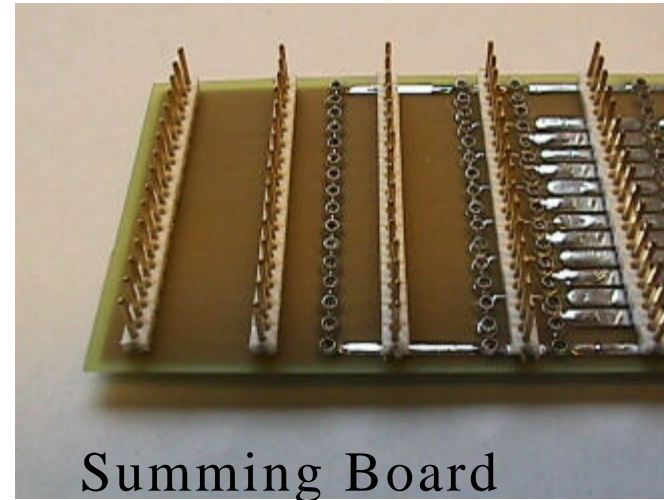
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ATLAS Calorimeter Electronics

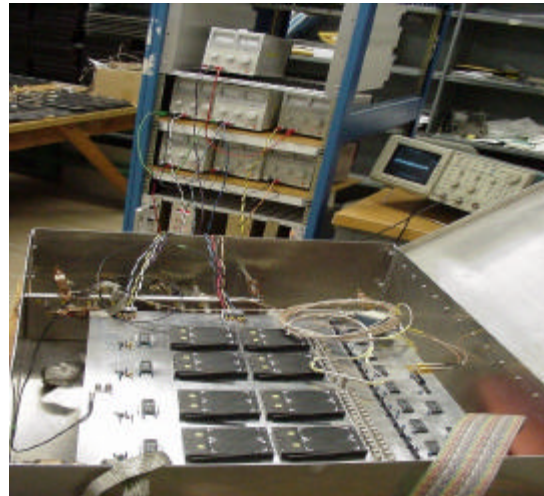


Motherboard



Summing Board

Test
Station



Crate Mock up

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RHIC Computing Facility (RCF) + ATLAS Tier I



RCF/ATLAS Processing Farm

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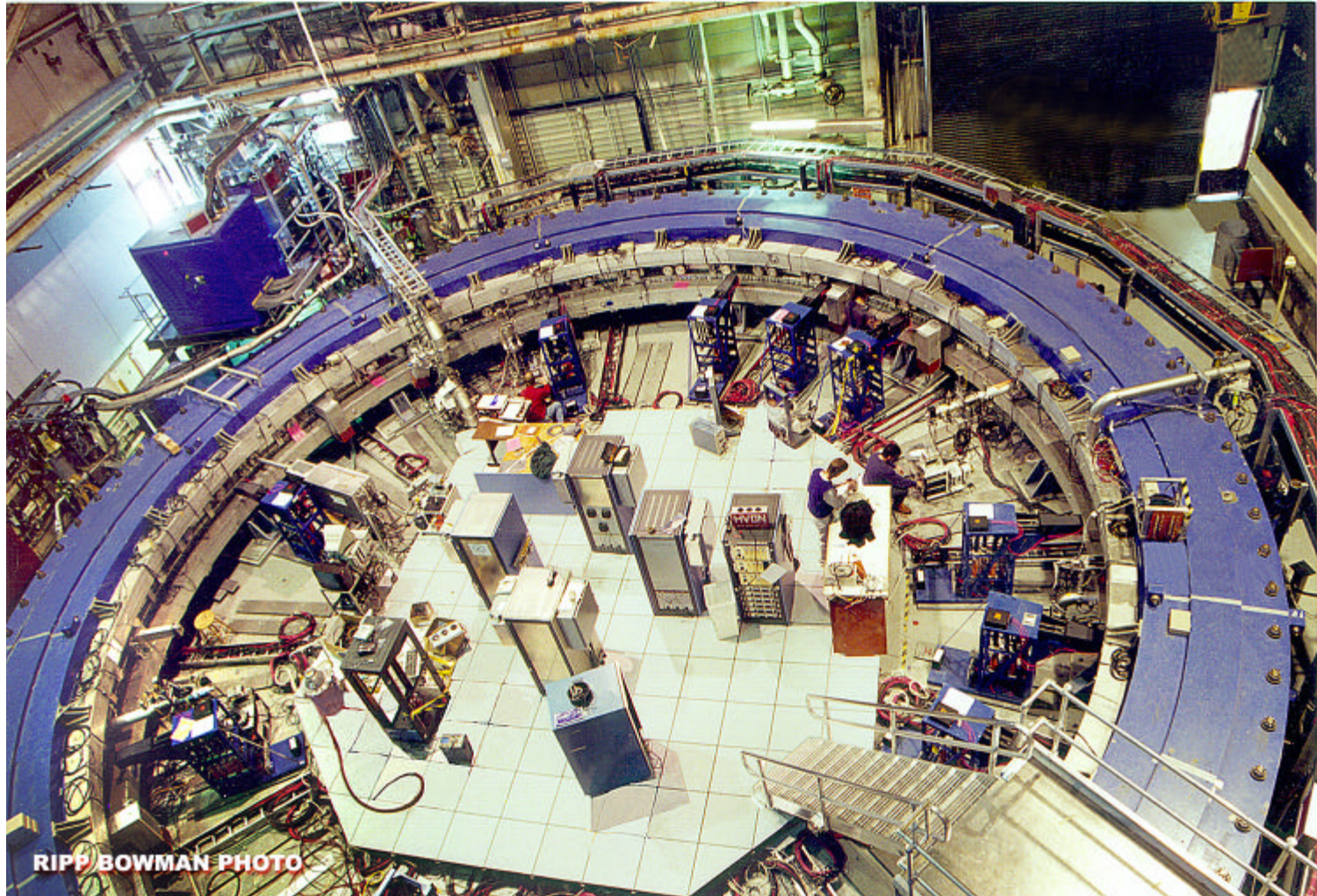


AGS Experiments (Muon g-2)

Experiments require very high rate low energy Kaon or muon beams often in dedicated modes

- **AGS E821 Precision Measurement of Muon (g-2)**
 - **High discovery Potential**
- Boston, BNL, Cornell, Fairfield, Heidelberg, Illinois, Minnesota, Novosibirsk, Sci. Univ. Tokyo, KEK, Yale
- Goal is a measurement of the anomalous magnetic moment of the muon at the 0.35ppm level (systematic errors are in hand)
 - a factor of 20 improvement over CERN experiment
 - sensitive to new physics (e.g. SUSY)
- Major Construction
 - Beam line, Construction of Muon (g-2) ring
 - Large (14m dia), high precision (< 1ppm) super conducting magnet
 - Detectors and magnet measuring system

The (g-2) ring



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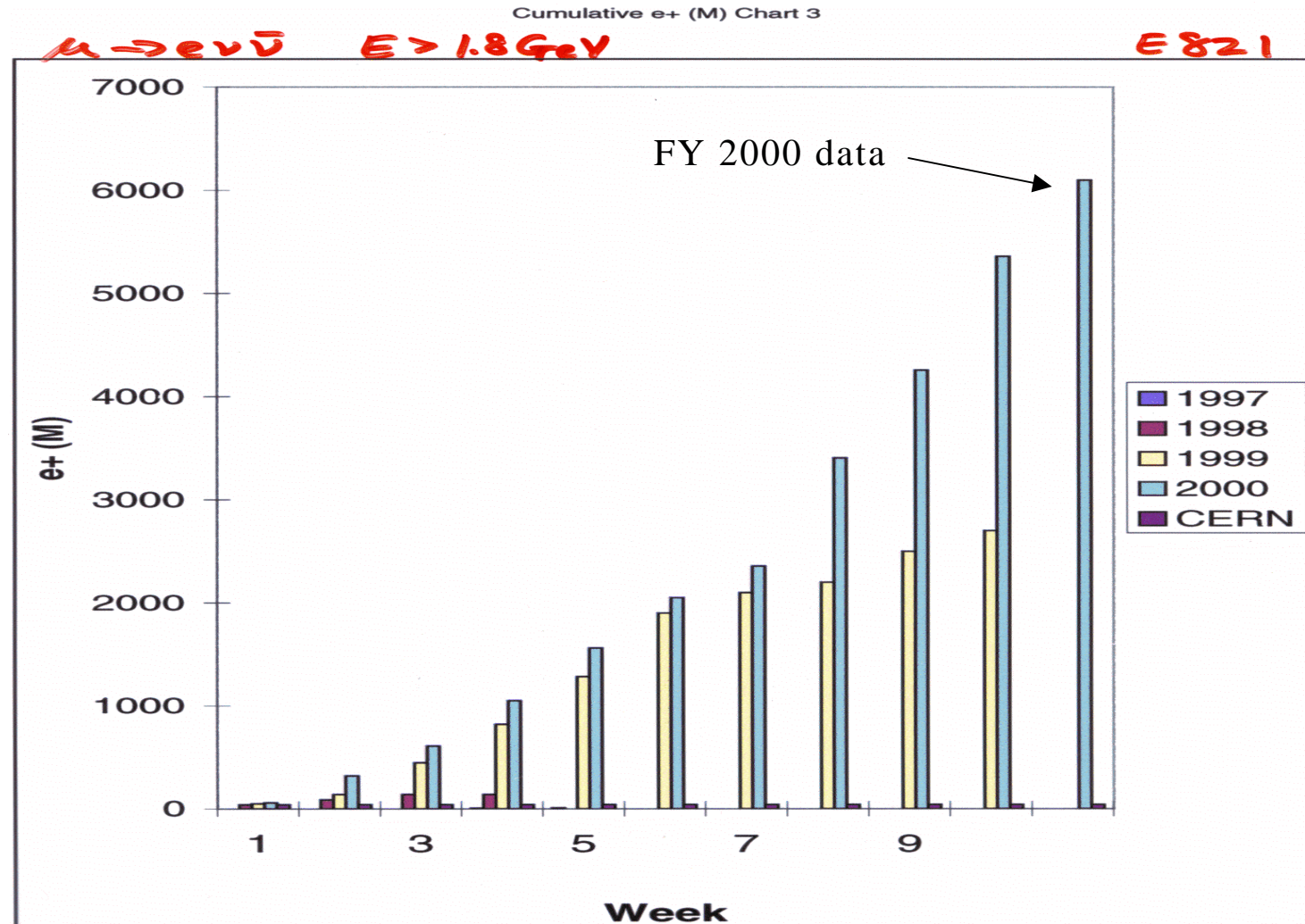


Muon (g-2) Measurement

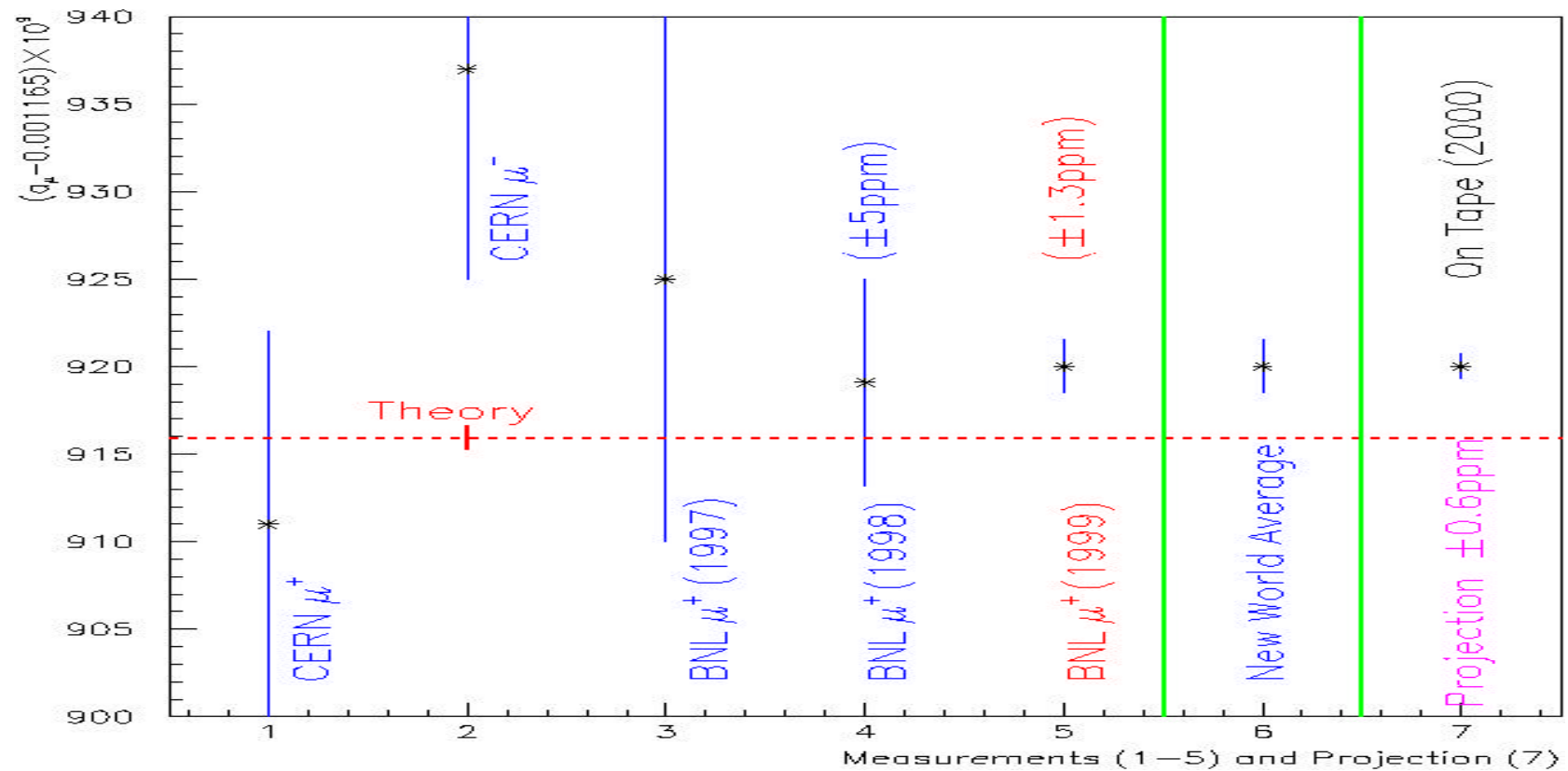
■ Progress

- FY 97
 - Pion injection, engineering/physics run
 - $10^7 \mu^+$ decays recorded ($da_\mu/a_\mu = 13\text{ppm}$)
R. Carey et al. Phys. Rev. Lett. 82 (1999)
- FY 98
 - Muon injection, engineering/physics run
 - $10^8 \mu^+$ decays recorded ($da_\mu/a_\mu = 5\text{ppm}$)
D. Brown. et. al. Phys. Rev D, 091101 (2000)
- FY 99, FY 00
 - FY 99, $2 \cdot 10^9 \mu^+$ decays recorded ($da_\mu/a_\mu = 1.3\text{ppm}$)
D. Brown et al. Phys. Rev. Lett. 86, 2227 (2001)
 - FY 00, $7 \cdot 10^9 \mu^+$ decays recorded ($da_\mu/a_\mu = 0.7 \text{ ppm}$)
- FY 01 Switched to μ^- running
 - Goal for FY 01 is $4 \cdot 10^9 \mu^-$ (15 week run scheduled)
- FY 02 Requesting 15 week run
 - Final goal is comparable errors on μ^- and μ^+

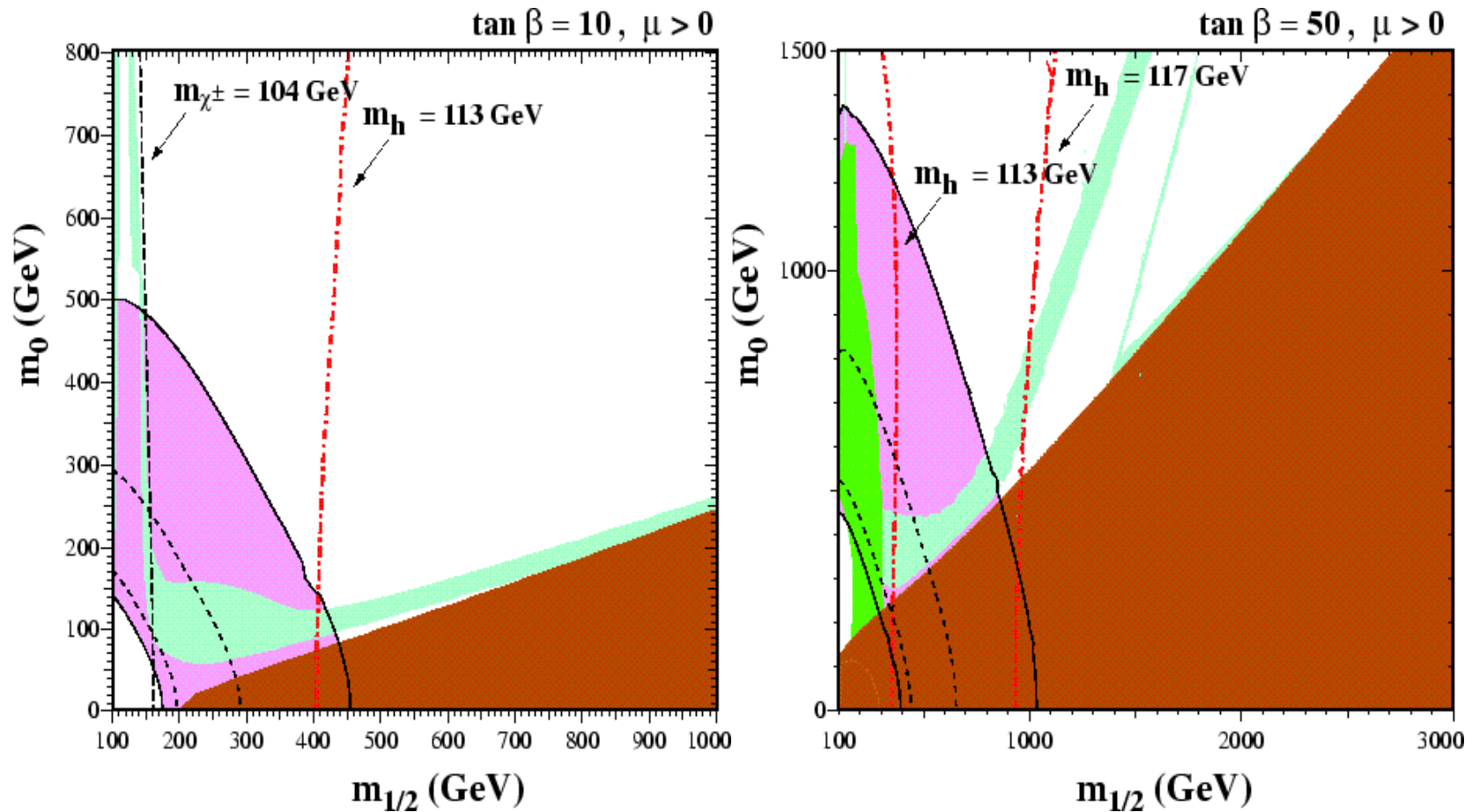
(g-2) Data Collection



Muon (g-2) results



(g-2) constraints on SUSY models



■ Ellis, Nanopoulos, Olive, hep-ph/0102331

AGS Experiments Rare Kaon Decays

■ AGS E787 Search for $K^+ \rightarrow \pi^+ \nu \nu$

BNL, Fukui, KEK, Osaka, Princeton, TRIUMF

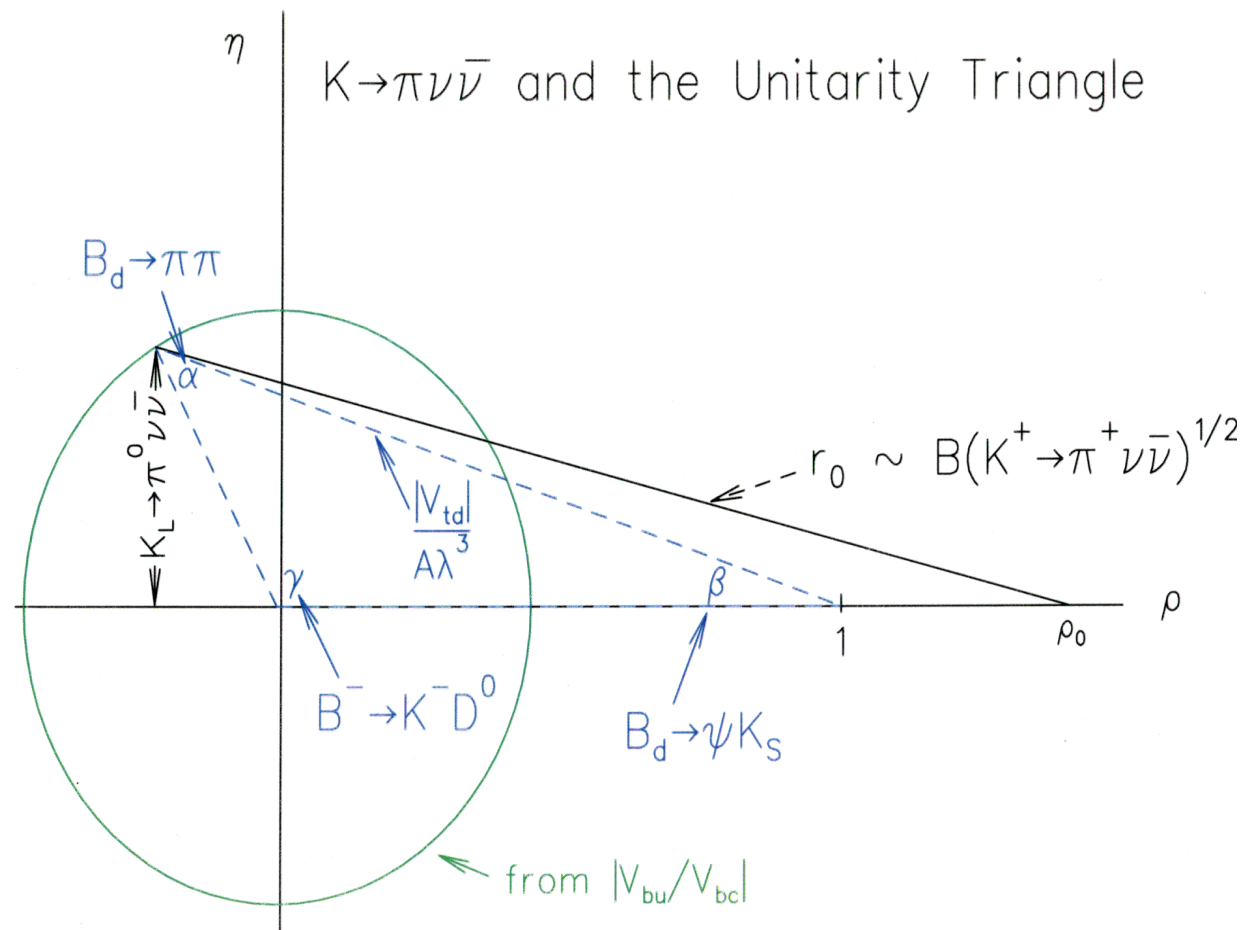
Decay is allowed in the Standard Model (V_{td})

■ Experiment is searching for other rare decays

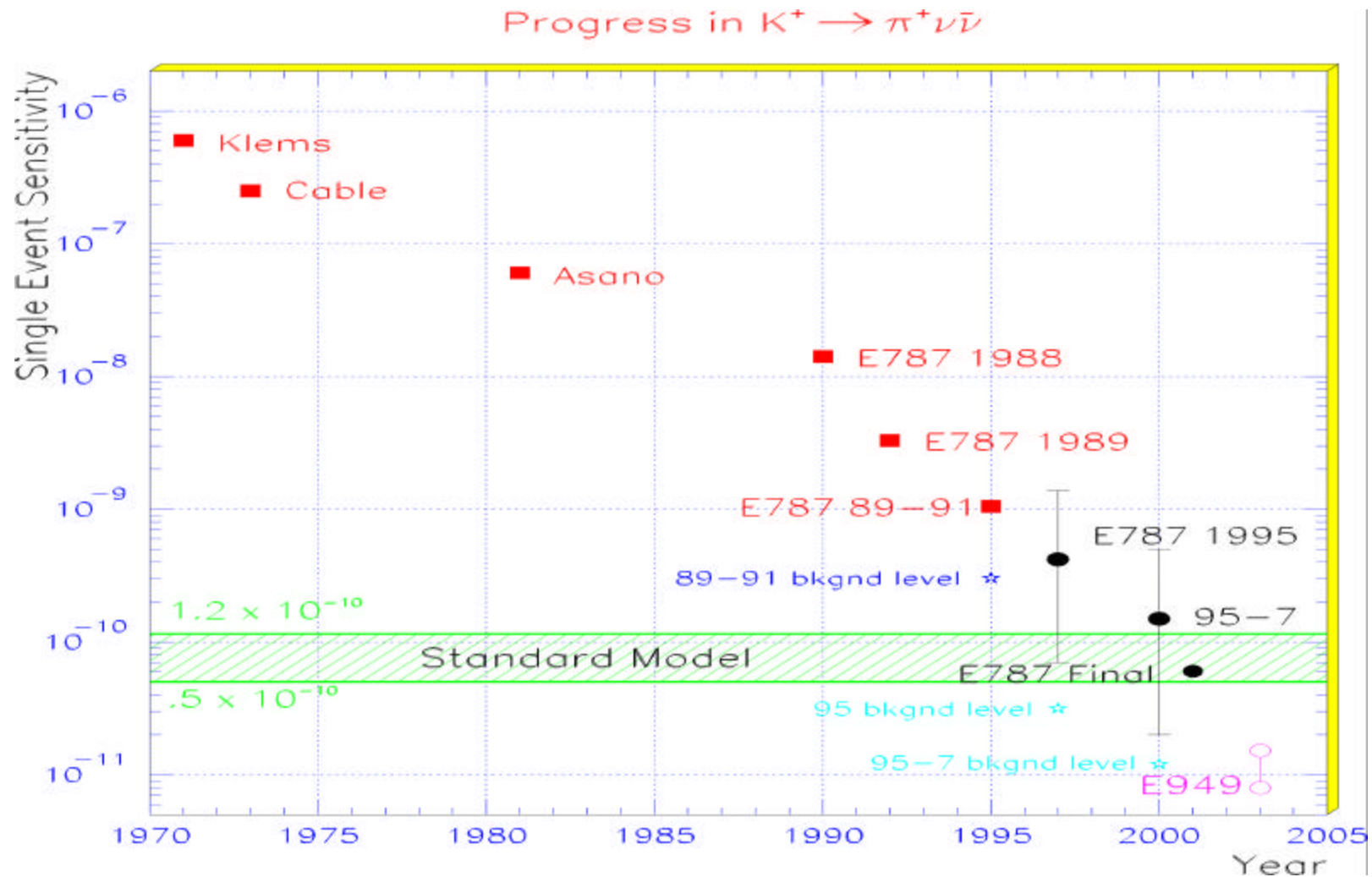
■ Status

- Data taking started in 1988, completed in 1998
- Major upgrade completed for FY 95 running
- 1988 - 1995 data (1 $K^+ \rightarrow \pi^+ \nu \nu$ event observed)
 - PRL 79, 2204 (1997)
- 1995-97 data (no new event observed)
 - PRL 84, 3768 (2000)
- 1998 data equal in sensitivity to previous total data
- Final result from all data is imminent

Unitarity Triangle



Summary of E787 Results



Rare Kaon Decays

■ AGS E949 Measurement of $K^+ \rightarrow \pi^+ \nu \nu$

- 20% V_{td} measurement (~ 10 events if Standard Model correct)
 - Discovery potential (present data consistent with 50 events)

■ Expanded collaboration including Fermilab

- Alberta, BNL, FNAL, Fukui, IHEP, INR-Moscow, KEK, Kyoto, New Mexico, Osaka, TRIUMF, Yeshiva

■ E787 detector with modest improvements

- Optimized running conditions
 - Larger Duty Factor , Lower momentum beam (more stopped Ks)
- Deadtime reduction, more on-line processing
 - Better photon vetoing, Improved trigger, DAQ, running efficiency
- Status
 - Upgrade almost completed
 - First data run 2001, data taking in 2002, 2003 (60 weeks total)

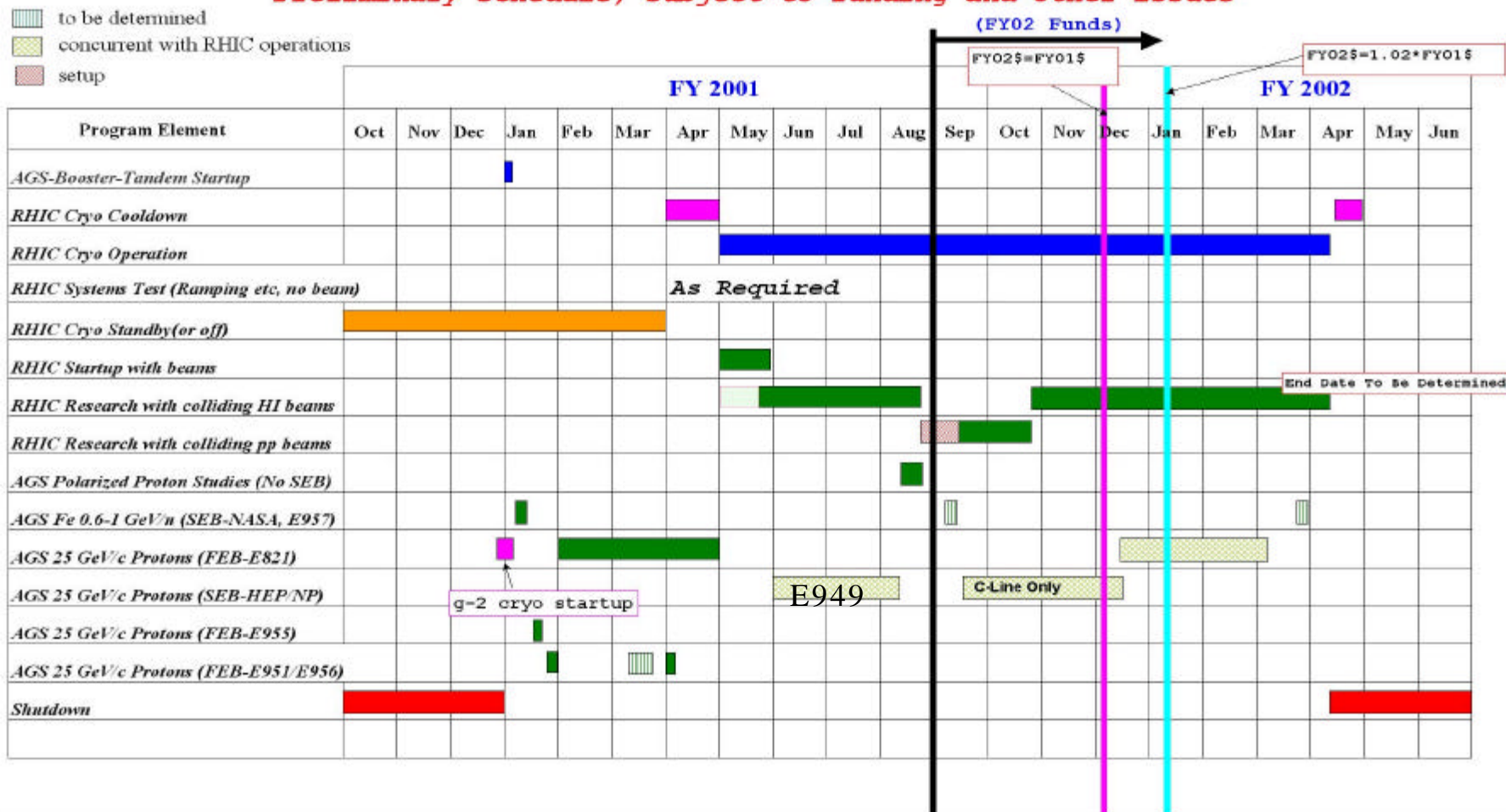
■ Fermilab CKM experiment ($K^+ \rightarrow \pi^+ \nu \nu$) ~ 80 events

- Brookhaven is a collaborator

C-A Operations-FY01-02

22 Feb 01

Preliminary schedule, subject to funding and other issues



NSF MRE Proposal

■ RSVP (Rare Symmetry Violating Processes)

- KOPIO ($K_L^0 \rightarrow \pi^0 \nu \nu$)
- MECO ($\mu \rightarrow e$ conversion; lepton number violation)

■ Status

- Selected by NSF as a Major Research Equipment (MRE) initiative for FY 2002
- Technical Design Review scheduled for Spring FY 2001
- R&D funding provided in FY 2001
- Awaiting budget decisions

RSVP - KOPIO

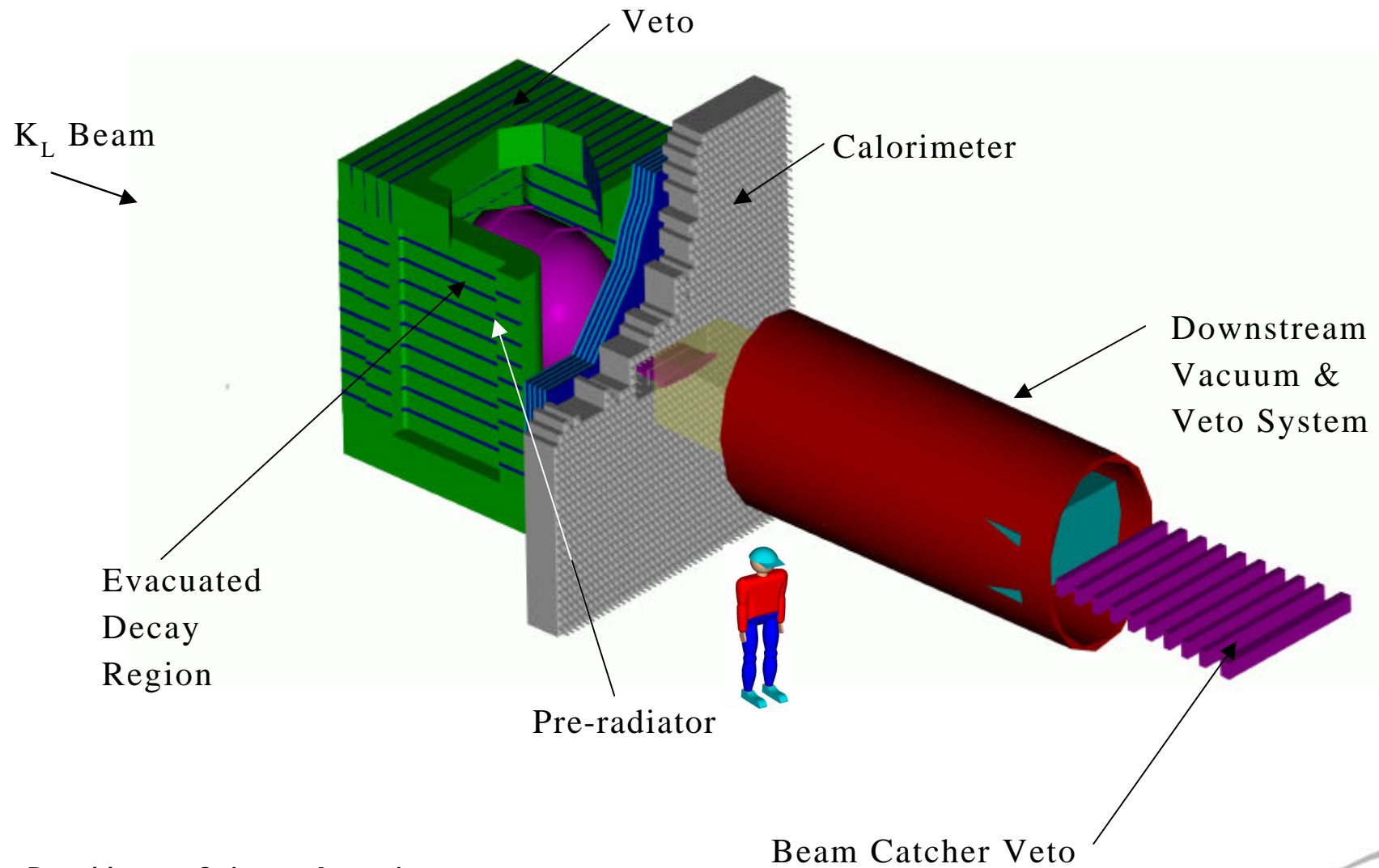
■ KOPIO ($K^0 \rightarrow \pi^0 \nu \nu$)

- BNL, Cincinatti, INR Moscow, Kyoto, VPI, New Mexico, TJLAB, TRIUMF, U. Va, Yale, Zurich

Spokespersons (D. Bryman, L. Littenberg, M. Zeller)

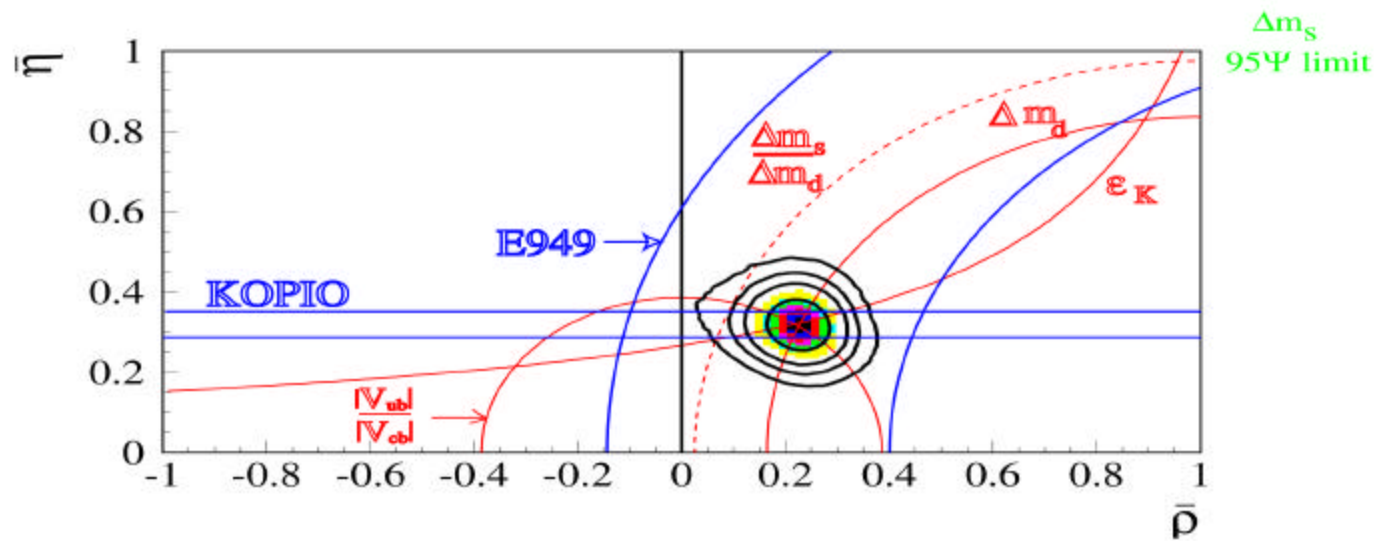
- Measurement of direct CP violation
 - Goal is 70 events (10% measurement of η)
- Requirements
 - High Flux ($4 \cdot 10^7$ K^0 per spill)
 - Low energy, bunched beam provides kinematic constraints on final state
 - Excellent background rejection (equivalent to E 787)
- Plans
 - Technical review Spring 2001
 - 3-4 years of construction
 - 90 weeks of running to reach initial goal

KOPIO



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E949 and KOPIO Constraints



Ciuchini et. al. Hep-ph/0012308

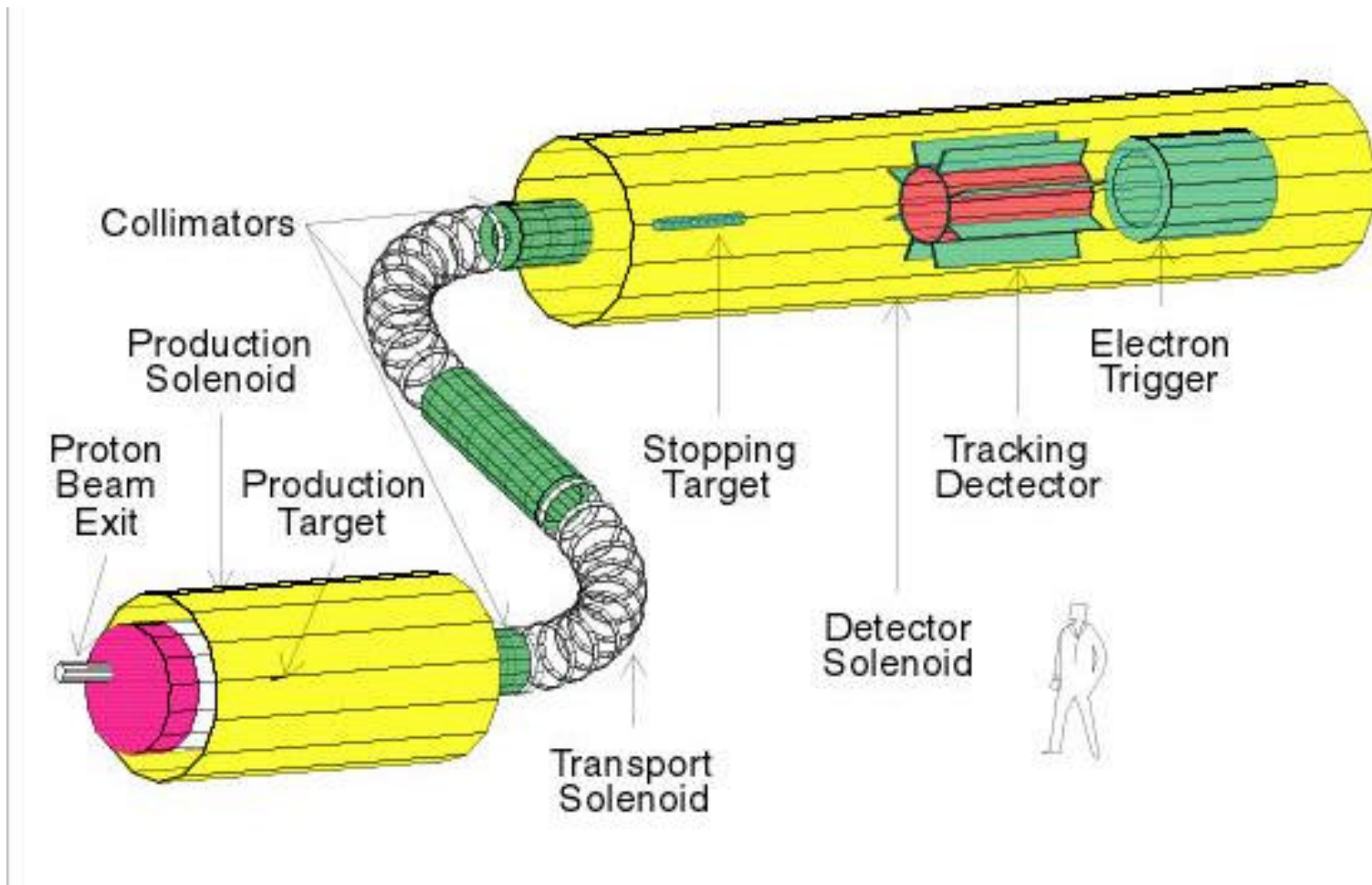
RSVP - MECO

■ MECO ($\mu \rightarrow e$ conversion)

– High Discovery Potential

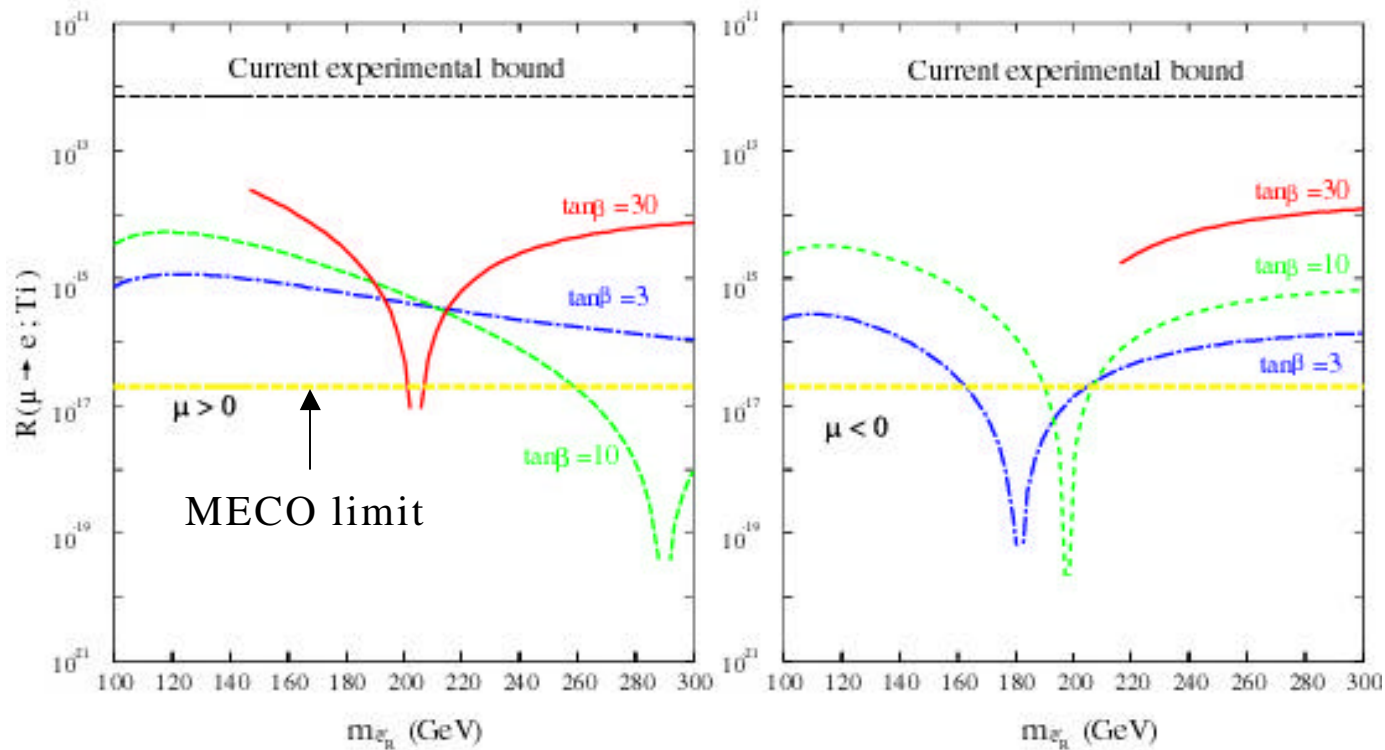
- BNL, Boston, Irvine, Houston, INR-Moscow, NYU, Penn, Perdue, Wm&Mary
 - Spokesperson W. Molzon
- Search for lepton number violation
 - Goal of experiment is to reach below 10^{-16}
 - Improvement of $\sim 10^4$ over present limits
- Requirements
 - high intensity muon beam
 - bunched beam with clean interbunch region
- Plans
 - Technical review Spring 2001
 - 4-5 year construction project
 - 40 weeks of running to reach initial goal

MECO Experiment



MECO

SUSY GUTS induce $\mu \rightarrow e$ conversion at level -



Hisano et. al. Phys. Lett B391, 341 (1997), hep-ph/96052965

Fermilab – D0

- Brookhaven Role in D0
- BNL was a founding member of D0
 - Design/Construction of Central Calorimeter (U/LAr)
 - Management of on-line/off-line computing effort
 - Co-leader of the top analysis effort; major role in W mass measurement
- Present role in Run 2
 - J. Kotcher, Associate Project Manager Installation and Commissioning
 - Lead responsibility for Forward Preshower Detector
 - Co-leader off line software group
 - Major role in DAQ software
 - Contribution to Forward Proton Detector; Muon system commissioning

Fermilab-D0 Forward Preshower



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Fermilab - MINOS

■ MINOS (Long Baseline Neutrino Oscillations)

- Brookhaven Role

- Leading study of sensitivity for $\nu_\mu \rightarrow \nu_e$ oscillations
 - Impact on beam design
- Members of beam monitoring working group
 - Detector tests at Brookhaven Accelerator Test Facility (ATF)
- Software development especially graphic displays

Summary and Conclusions

■ Brookhaven High Energy Physics program

- Strong and Diverse program
- Well focused on key aspects of national program
- Senior leadership positions in almost all activities
- Innovative scientific and technical contributions
- High discovery potential
 - AGS program
 - E821 (g-2), E787/E949 ($K^+ \rightarrow \pi^+ \nu \nu$)
 - NSF MRE RSVP (KOPIO, MECO)
 - Fermilab
 - D0
 - MINOS
 - ATLAS
 - Muon Collider/Neutrino Storage Ring R&D
 - Theory